A1570 EMAT

OEM Ultrasonic Pulser-Receiver Units

User manual

Revision 1.0.3

Acoustic Control Systems - ACS Group
Saarbrücken, Germany 2024

This instruction manual contains essential information on how to use this ACS product safely and effectively.
Before using this product, thoroughly review this instruction manual. Use the product as instructed.

1 Description and instrument operation

1.1 The intended use of the instrument

1.1.1 Intended use and application range

The instrument is a portable ultrasonic thickness gauge of general purpose.
The instrument is designed for measurement of thickness of parts and walks of steel tubes and objects made of steel and metal alloys without the use of coupling fluids; ultrasonic thickness measurements of flat rolled stock; ultrasonic thickness measurements of the ship bottom without pretreatment of the surface; evaluation of anisotropy degree of the material.
The instrument can be used under the laboratory, field and workshop conditions in various industries.

The instrument communicates with a PC via the TCP/IP network (LAN or WLAN).

1.1.2 Operating conditions

The instrument is designed to work under the following conditions:
- ambient air temperature range from –30 to + 55 C;
- relative air humidity up to 95% at +35 C.

1.2 Technical specifications

The main metrological specifications of the instrument are listed in the Table 1 4 .

Table 1: Metrologic specification

Parameter	Value
Measurement range in steel with following transducers, mm:	
– S3850 5.0A0D8ES	from 1 to 100,0
– S3955 4.0A0D8ES	from 1 to 100,0
– S7392 4.0A0D10ES	from 1 to 100,0
– S7394 3.0A0R10x10ES	from 1 to 200,0
Measurement accuracy in steel depending on nominal thickness value d, mm	±(0,01·d + 0,02),

The main technical specifications of the instrument are listed in the Table 2 4 .

Table 2: Technical specification

Parameter	Value
Setting range of the ultrasonic sound velocity, m/s	from 500 to 15 000
Operating frequency range, MHz	from 2,5 to 5,0
Power source #1	15V Power supply
Power source #2	18650 li-ion Battery
Rated supply voltage, V	13,2
Period of continuous operation of the instrument powered by the battery under normal environmental conditions, min, h	> 8
Overall dimensions of the electronic unit, mm	
– length	284
– width	170
– height	62
weight of the electronic unit, g	2000
Average service life, years	>5

1.3 Design and operation

1.3.1 Design

In general, the instrument is an electronic unit with replaceable electromagnetic ultrasonic transducers (EMAT) connected via cables.

Figure 1: Overview of the device and EMAT

Front Panel

Figure 2: Front panel of the device

The front panel of the device includes:

- **Power button**: Used to turn the device on and off.
- **Connectors Lemo00 and Lemo2K**: For connecting EMAT.
- **LEDs**: Indicate the status of the device.

Rear Panel

The rear panel of the device has the following elements.

Figure 3: Rear panel of the device

- M12-Female connector for Ethernet
- M8-Female connector for power supply
- M12-Female connector for external trigger
- Connector for WLAN antenna
- Micro-USB connector for maintenance

The rear panel of the device includes:

- **M12-Female connector**: For Ethernet connection.
- **M8-Female connector**: For power supply connection.

- **M12-Female connector**: For external trigger.
- **Connector for WLAN antenna.**
- **Micro-USB connector**: For maintenance purposes.

Bottom Surface

The bottom of the device houses the battery compartment.

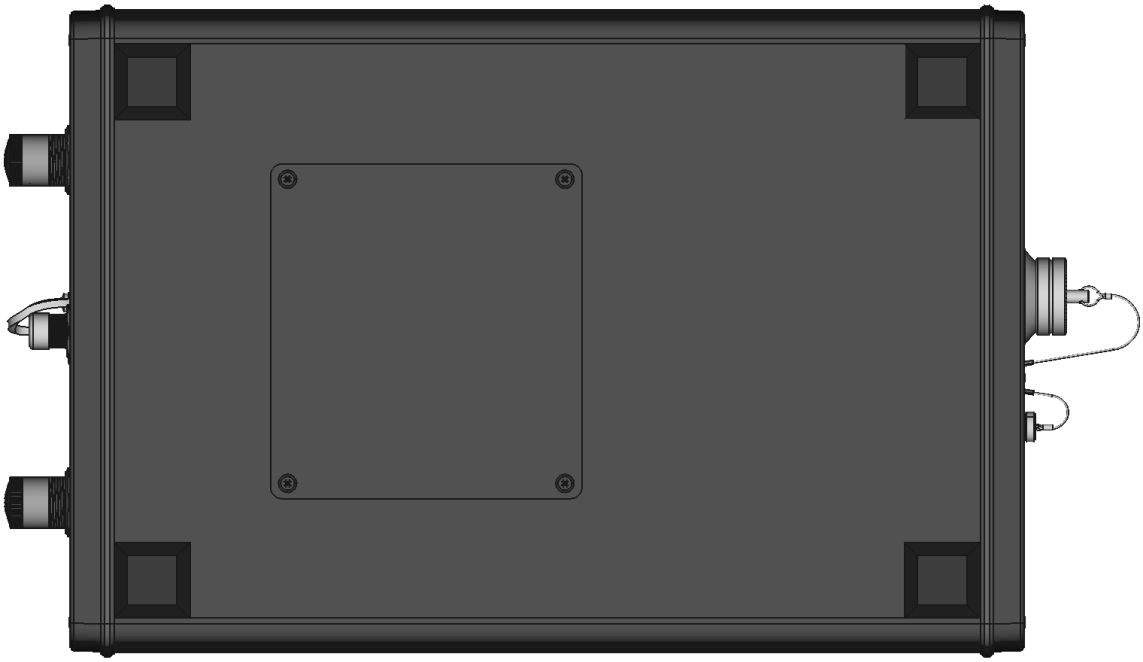

Figure 4: Bottom surface of the device

A1570 Battery compartment

General information

The device uses 18650 li-ion batteries. Batteries can be replaced through the removable battery cover.

WARNING The replacement of the batteries shall only be carried out by personnel that is qualified to handle batteries.

WARNING Only 18650 li-ion batteries shall be used with the A1270 device, or the device will malfunction or be destroyed.

WARNING When changing batteries, always pay attention to the correct polarity or the device will malfunction or be destroyed.

General safety guidelines for the use of Li-Ion batteries.

WARNING These general guidelines do not replace the qualification requirement by the employer:

- Handle discharged batteries with care.

Discharged batteries are also a source of danger, as they can still cause a very high short-circuit current. Therefore, even if lithium-ion batteries appear to be in a discharged state, they should be treated with the same care as if they were not discharged.

- Avoid physical impacts/blows.

Blows and ingress of objects can damage the battery. This can lead to leakage, heat, smoke, ignition or explosion of the battery.

- Keep batteries away from other metallic objects.

E.g. paper clips, coins, keys, screws or other metal objects, can cause a bypass of the terminal contacts. A short circuit between the battery contacts can result in burns or fire.

- If used incorrectly, liquid may leak from the battery.

Avoid contact with it. In case of accidental contact, rinse with water. If the fluid gets into the eyes, seek additional medical attention. Leaking battery fluid can cause skin irritation or burns.

- Do not expose batteries to fire or high temperatures.

If batteries are thrown into a fire or exposed to temperatures above 130°C, the heat build-up can lead to an explosion and/or fire and injury to people. Do not burn batteries!

- Do not disassemble the battery.

Disassembling or altering the battery may damage the protections. This can lead to heat, smoke, ignition or explosion of the battery.

- Do not submerge the battery in liquids such as water or beverages.

Contact with liquids can damage the battery. This can lead to heat, smoke, ignition or explosion of the battery.

- Charge batteries only in chargers recommended by the manufacturer.

For a charger that is suitable for a certain type of battery, there is a risk of fire if it is used with other batteries.

- Use batteries only with dedicated electrical device.

The use of any other electrical device may result in injury or fire.

- Do not use damaged or altered batteries.

Damaged or altered batteries may have unpredictable characteristics that may result in fire, explosion or injury.

- Do not use faulty batteries.

The use of a battery must be stopped immediately as soon as it shows abnormal properties, such as odour, heat, discolouration or deformation. With continued operation, the battery may develop heat and smoke, ignite or explode.

Storage

In any case, the warnings on batteries and the instructions for use must be carefully observed. Use only the recommended types of batteries. Lithium batteries should preferably be stored at room temperature and in a dry place (max. 50°C). Large temperature fluctuations should be avoided. (e.g. do not store near heaters, do not permanently expose to solar radiation).

Battery disposal

The battery shall not be disposed of with normal domestic waste. Please refer to the regional guidelines on battery separation. The proper disposal of batteries protects against potential and negative effects on the environment and human health.

Battery replacement Instructions

- Do not use excessive force when loosening or fastening screws.
- Use a fitting screwdriver according to ISO 7046 size M2.
- Do not exceed a torque of 0.25 Nm.
- Place the device in a clean, secure area.
- Remove screws by turning them counterclockwise and store them safely (see Figure 5 10).
- Lift off the lid carefully.
- Replace batteries, observing correct polarity printed in the battery compartment (see Figure 7 11).
-  **WARNING** Ensure sealing cord is in the designated groove and lid is in place. If the sealing cord is displaced or removed, the device enclosure is not sealed against water intrusion. This will circumstantially lead to damaging the device.
- Insert screws and turn them clockwise until fastened. Observe torque limit of 0.25 Nm.

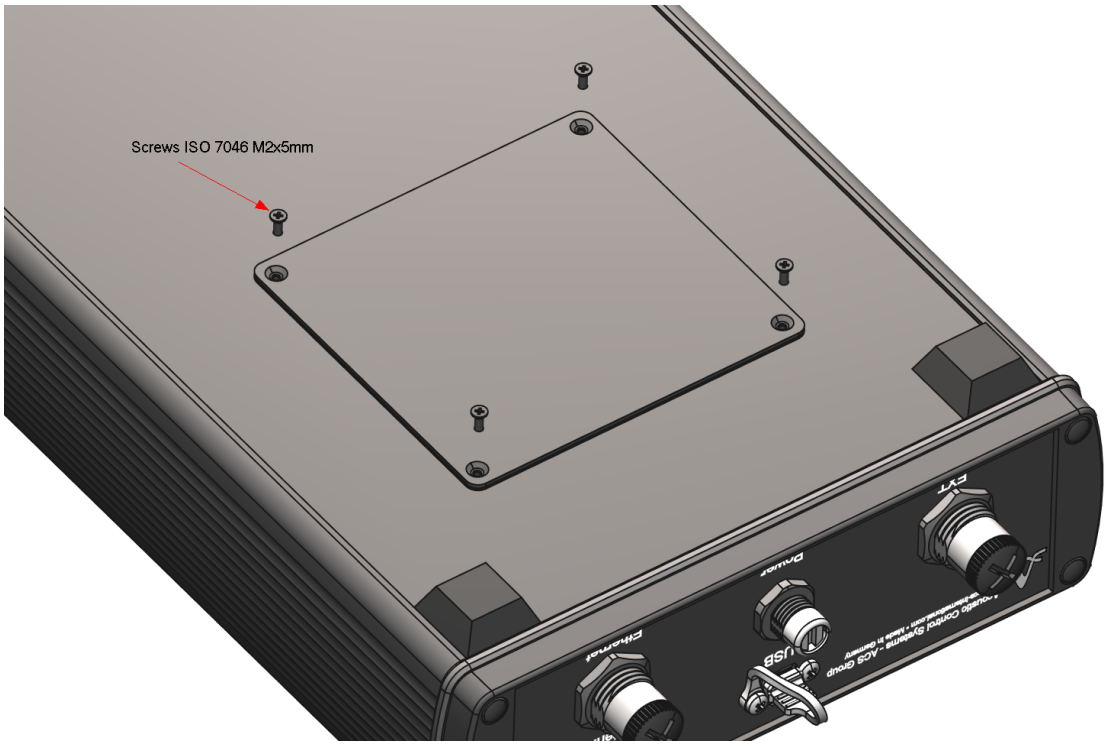

Figure 5: Removing screws from battery compartment

Figure 6: Battery compartment

To replace the batteries, follow these steps:

- Remove the old batteries and dispose of them properly.
- Insert the new batteries, ensuring you follow the safety guidelines and observe the correct polarity. The polarity markings are printed at the bottom of the battery compartment (see Figure 7 11).

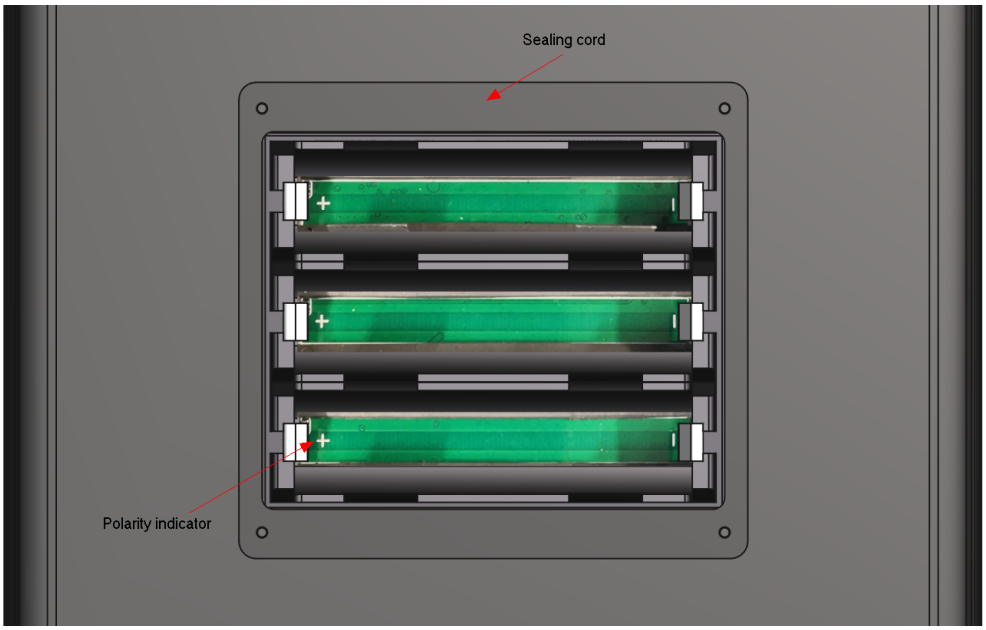

Figure 7: Battery compartment

2 Proper use

2.1 Preparing the instrument for operation

2.1.1 Connecting the transducers

EMAT is used to measure the thickness of the inspected object.

The instrument uses two types of *transverse* wave EMATs: radial and linear polarization, both based on pulsed and permanent electromagnet technologies.

- EMAT S3850 5.0A0D8ES: This type has radial polarization and an electric solenoid. This type should be connected to "LEMO 2K" connector.
- EMAT S7392 3.0A0D10ES and EMAT S7394 2.5A0R10x10ES: These types have permanent solenoids and can be connected to the instrument's electronic unit using "LEMO 00" connector.

IMPORTANT Observe the markings on the cable and connector to ensure proper connection (see Figure 8 12).

Figure 8: Lemo connectors of A1570

2.1.2 Switching On/Off the instrument

The device offers the following options for power management:

A. Batteries present; power supply not connected or turned off

To turn on the device, press the "Power" button on the front panel for more than 3 seconds.
- All LEDs will initially turn on to indicate the start of device initialization.
- The LEDs will then cycle through from "10%" up to the current state of charge (SoC) of the batteries.
- If no errors are detected, the "100% ON" LED will light up, indicating the device is ready for use.

To turn off the device press the "Power" button on the front panel for more than 3 seconds.

B. Batteries present; power supply connected and turned on

When the power supply is turned on, the device will automatically turn on.
- The loading procedure is similar to the first scenario.
- The difference is that the LEDs from "10%" and up will remain constantly lit.

The device remains on as long as the power supply is connected and turned on. If the power supply is disconnected, follow the procedure outlined in the first scenario

C. No batteries; power supply connected

When the power supply is turned on, the device will automatically turn on.
- The loading procedure is similar to the first scenario.
- However, the state of charge will not be shown.

The device remains on as long as the power supply is connected and turned on. If the power supply is disconnected, the device will shut down immediately.

Attaching power supply

To attach the power supply, remove protective cap and carefully screw the 4-pole M8 plug into the corresponding connector. Then, plug the power supply into an electric outlet.

For further information, please refer to the "Maintenance" 15 section.

2.1.3 Connecting LAN-cable

The device connects to the user's environment via LAN cable or WLAN.

Using a LAN connection:

1. Connect the 4-pole M12 LAN cable to the device. You can use the cable from the delivery kit or any suitable LAN cable with the appropriate plug.
2. Remove the protective cap from the device before plugging in the cable.

IMPORTANT Ensure the cable and connector use A-coding for compatibility (see Figure 9 14).

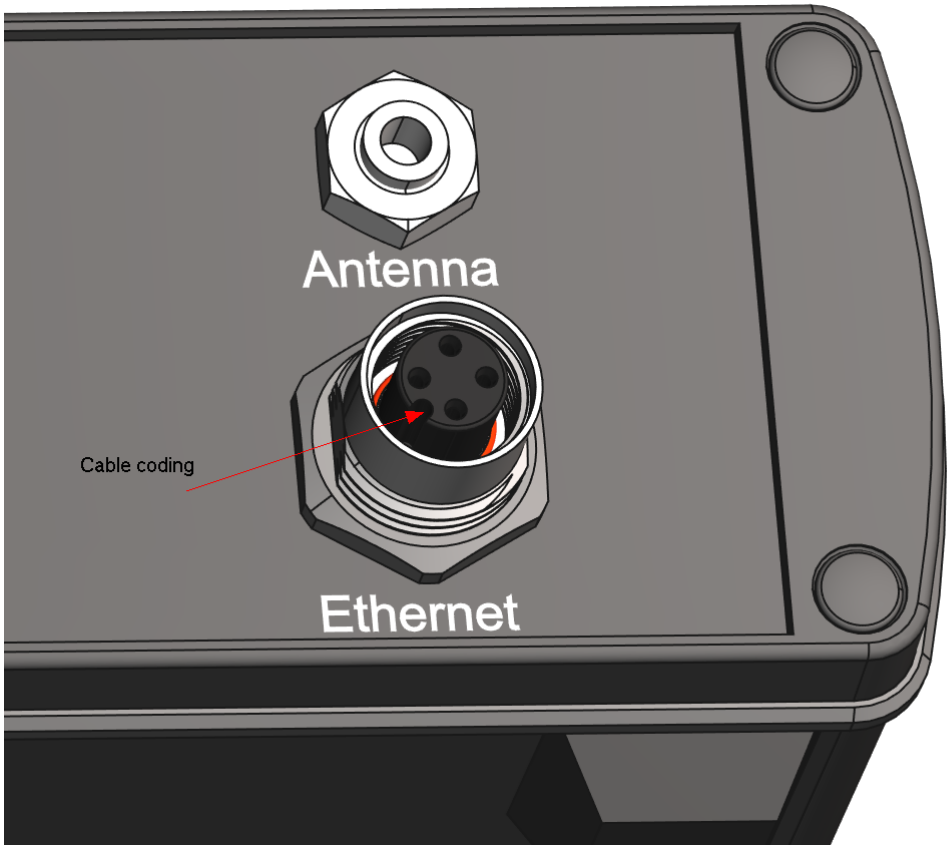

Figure 9: LAN connector

2.2 Using the instrument

2.2.1 Working with the instrument

During the inspection the temperature dependence between the ultrasonic propagation velocity in cooled or heated materials shall be considered. For the best measurement results the instrument must be adjusted to the ultrasonic velocity by the calibration sample with the same temperature as the temperature of the inspected object.

3 Maintenance

Maintenance of the thickness gauge includes the following:
1. Cleaning: Regularly clean the electronic unit to remove dust and dirt.
2. Charging: Charge the rechargeable battery as needed.

3.1 Accumulator

The rechargeable battery is designed to be operated in a broad temperature range. At negative temperatures battery capacity decreases. At lower temperatures the battery capacity is 15% less as compared to the normal temperature conditions.
If the rechargeable battery goes dead the instrument will be switched off automatically.
The rechargeable battery has a built-in protection against overcharge, over discharge, over current and overheating.
The battery service life is designed for the whole guaranteed service life of the instrument.
The battery must be replaced by the service centers only.


WARNING THE WARRANTY WILL BE VOIDED IF THE USER REPLACES THE BATTERY INDEPENDENTLY!

3.2 Charging the battery

The battery shall be charged via an external charger.
The battery charging time depends on the discharge level. The complete charging takes maximum 2 hours. Multiple recharging is allowed.


You can conduct the measurements during battery charging.


WARNING TO AVOID THE BATTERY DAMAGE DON'T STORE THE INSTRUMENT WITH THE DISCHARGED ACCUMULATOR!

3.3 Check battery state of charge

If the batteries are present and there is no error, you can check the state of charge (SoC) of the entire battery pack. To do this, press the power button briefly.
- If there is no connected power supply or the power supply is turned off, the LEDs will light up sequentially from "10%" to the current SoC several times.
- If a power supply is connected and turned on, the LEDs from "10%" to the current SoC will light up simultaneously for 2 seconds.

After checking the SoC, the LEDs will return to their previous state.

3.4 Troubleshooting

If you have questions about operating the thickness gauge, contact the manufacturer's representatives for assistance and expert consultation.

3.4.1 Error messaging via LEDs

If error occurred in runtime, LEDs provide the code of the error. On error state the LED "10% Error" will briefly on following by an error code. Please consult the following tables to find out the error source.

State of LEDs indicating error code:

Error code	LED "10%"	LED "25%"	LED "50%"	LED "75%"	LED "100%"
1	ON				
2		ON			
3	ON	ON			
4			ON		
5	ON		ON		
6		ON	ON		
7	ON	ON	ON		
8				ON	
9	ON			ON	

Please find error codes description in the table below:

Error code	Error description
1	General error
2	Temperature of battery is out of range (low or high)
3	Battery Temperature Sensor Failure
4	Charger Failure
5	Battery Voltage Fault (over- or undervoltage)
6	Battery Gauge Error
7	FPGA error
8	Battery low state of charge warning
9	Battery low state of charge error

4 Transportation

The thickness gauge should be transported in the case included in the delivery kit.
The packaged instruments can be transported by any vehicle types for any distances without speed restrictions.
The packaged instruments shall be properly fastened in the transport vehicle. The packaged instruments shall be protected from precipitation and water splashes if the instruments will be transported in an open transport vehicle.
The packaged instruments should be properly and steadily fixed to prevent shocks of devices against each and against vehicle walls during the transportation.
The transportation conditions should confirm to the requirements of the technical conditions and regulations applicable to each type of transportation.
If shipped by air transport, properly packed instruments should be placed in hermetically sealed and heated compartments.
In case the transportation conditions differ from the operation conditions, the instruments shall be kept under normal environmental conditions for at least 2 hours prior to operation.

5 SCPI Programming Manual

This manual provides detailed information about the SCPI commands and queries that are available for communicating with A1570 instruments.

Related Documents and Resources

- Standard Commands for Programmable Instruments (SCPI), Volume 1-4, Version 1999.0 May 1999, SCPI Consortium
- IEEE Std 488.2-1992, The Institute of Electrical and Electronics Engineers
- IEC 60488-2:2004, Standard digital interface for programmable instrumentation - Part 2: Codes, formats, protocols and common commands
- https://www.ivifoundation.org/resources/default.aspx
- https://www.ivifoundation.org/shared_components/

5.1 Conventions

The following conventions are used throughout the manual.

Syntax

<>	indicates a particular type of data
[]	part within squared brackets can be omitted
{}	indicated that one of items must be selected. A vertical bar | separates individual items.
space	separates commands from parameters
,	used to separate adjacent parameters

Data types

Data types	Parameter	Description
<numeric>	Number	{<integer>|<real>}
<frequency>	Frequency	<numeric>{[HZ]|KHZ|MHZ|GHZ}
<time>	Time	<numeric>{[S]|MS|US|NS|PS}
<numeric list>	Numeric list	<numeric 1>,<numeric 2>,...,<numeric N>
<bool>	Boolean parameter	{0|1|ON|OFF}
<char>	Character parameter	Predefined set of character strings without quotes
<string>	String parameter	Quoted string
<binary array>	Binary array	Binary array

5.2 Commands and Queries

5.2.1 Common Commands and Queries

5.2.1.1 Identification query *IDN?

Description	This query returns the unique identifier of the instrument
Syntax	*IDN?
Parameter	None
Query Response	Manufacturer, Model, Serial number, Firmware version
Data Format	<arbitrary ASCII response data>
Name	Manufacturer
Description	Defines the manufacturer of the instrument. For example: `ACS-Solutions GmbH`.
Name	Model
Description	Identifies the model of the instrument (for example `A1570`).
Name	Serial number
Description	Identifies the serial number of the instrument (for example: `1190065)`.
Name	Firmware version
Description	Identifies the version of firmware that is loaded on the instrument (for example: `1.23`).
Example	`> *IDN?` `< ACS-Solutions GmbH,A1570,123456789,ESP 1.25 MCU 6.01.244`

5.2.2 Device Command and Queries

SOURce Subsystem 23

Command/Query	Mnemonic	Link
Start vectors acquisition	[SOURce:]STARt?	see 23
Start thickness measruement	[SOURce]:STARt:MEASurement	see 23
Start probe calibration in air	[SOURce]:STARt:CALibration:AIR	see 23
Start probe calibration on object surface	[SOURce]:STARt:CALibration[:OBJect]	see 24
Stop acquisition	[SOURce:]STOP	see 24
Constant gain at input	[SOURce:]GAIN[:LEVel]?	see 24
Acquisition triggering mode	[SOURce:]TRIGgering:MODE?	see 25
Periodic acquisition interval	[SOURce:]TRIGgering:INTerval?	see 26
Input sampling rate	[SOURce:]FREQuency?	see 27
Transmitter burst frequency	[SOURce:]TRANsmitter:FREQuency?	see 28
Transmitter pulse amplitude	[SOURce:]TRANsmitter:PULSe[:LEVel]?	see 29
Transmitter burst period	[SOURce:]TRANsmitter:PERiod?	see 29
Transmitter burst duration	[SOURce:]TRANsmitter:DURation?	see 30
Transmitter enable	[:SOURce]:TRANsmitter:ENABle?	see 31
Transducer polarity mode	[SOURce:]TRANsmitter:MODE?	see 31
Sound velocity	[SOURce]:VELocity[:SOUNd]	see 32
Zonder mode	[SOURce]:ZONDer:MODE	see 32

SENSe Subsystem[33]

Command/Query	Mnemonic	Link
Acquisitions per averaged vector	[SENSe:]AVERage:COUNt?	see[33]
Constant averaging interval	[SENSe:]AVERage:PERiod?	see[34]
Random averaging interval	[SENSe:]AVERage:PERiod:RANDom?	see[35]
Delay between starting of magnet and acquisition begin	[SENSe]:MAGNet:DELay?	see[36]
Turn on magnet during data acquisition	[SENSe]:MAGNet:ENABle?	see[37]
Magnet voltage setting	[SENSe]:MAGNet:VOLTage?	see[37]
Probe delay for thickness measurement	[SENSe]:PROBe:DELay[:PROCessing]	see[38]
Probe type	[SENSe]:PROBe[:TYPE]	see[39]
Dead zones	[SENSe]:DEZones	see[39]
Noise properties	[SENSe]:CALibration:NOISe	see[40]
Eddy current properties	[SENSe]:CALibration:EDARray	see[41]
Enabling software averaging	[SENSe]:SOAVerage[:ENABle]	see[42]
Software averaging limit	[SENSe]:SOAVerage:COUNt	see[42]

FETCh Subsystem[43]

Command/Query	Mnemonic	Link
Fetching A-Scan vector	FETCh[:ARRay]?	see[43]
Fetching measurement result	[FETCH]:RESult[:MEASure]?	see[44]

SYSTem Subsystem[45]

Command/Query	Mnemonic	Link
Count of detected errors	SYSTem:ERRor:COUNt?	
Reads out error message queue	SYSTem:ERRor[:NEXT]?	see 45
Version of SCPI standard	SYSTem:VERSion?	

STATus Subsystem 46

Command/Query	Mnemonic	Link
Read battery state of charge	[STATus]:BATTery?	see 46
Read charging status	[STATus]:CHSTatus?	see 46

5.2.2.1 SOURce Subsystem

5.2.2.1.1 Start acquisition

Description	Method will start an acquisition of A-Scans
Syntax	[SOURce]:STARt[:ASCAN]
Notes	Once started, a sequence of acquisitions will be continued by the instrument even if the instrument disconnected.
Example	`> SOUR:STAR`

Description	Method will start thickness measurement
Syntax	`[SOURce]:STARt:MEASurement`
Notes	Start continuous thickness measurement
Example	`> SOUR:STAR:MEAS`

Description	Read actual state of measurement
Syntax	`[SOURce]:STARt[:ASCAN]?`
Notes	Return 1 if the acquisition is started, 0 otherwise
Example	`> SOUR:STAR?`

5.2.2.1.2 Start thickness measurement

Description	Method will start thickness measurement
Syntax	[SOURce]:STARt:MEASurement
Notes	Start continuous thickness measurement
Example	`> SOUR:STAR:MEAS`

5.2.2.1.3 Start calibration in air

Description	Method will start EMAT calibration in air
Syntax	[SOURce]:STARt:CALibration:AIR
Notes	After the calibration its result will be saved in internal memory until the next device start
Example	`> STAR:CAL:AIR`

5.2.2.1.4 Start calibration on object

Description	Method will start EMAT calibration on calibration object
Syntax	[SOURce]:STARt:CALibration[:OBJect]
Notes	After the calibration its result will be saved in internal memory until the next device start
Example	`> STAR:CAL`

5.2.2.1.5 Stop acquisition

Description	The method is used to stop a sequence of measurements.
Syntax	[SOURce:]STOP
Example	`> SOUR:STOP`

5.2.2.1.6 Constant gain at input

Description	This property sets or gets analog amplification in decibels
Syntax	[SOURce:]GAIN[:LEVel] <numeric | char> [SOURce:]GAIN?
Parameter	<char> = {MINimum | MAXimum | DEFault | UP | DOWN} <numeric> {0 to +40 dB} • MINimum - 0 dB • MAXimum - +40 dB • DEFault - 0 dB • UP - increases the current value by 1 dB • DOWN - decreases the current value 1 dB
Unit	dB - decibel
Query Response	<numeric> in decibel
Notes	Default units are dB. The suffix dB can be omitted.

Example	`> GAIN:LEV 10 DB`
	`> GAIN?`
	`< 10`

5.2.2.1.7 Acquisition triggering mode

Description	This property is used to choose which event initiates an acquisition.
Syntax	[SOURce:]TRIGgering:MODE <char> [SOURce:]TRIGgering:MODE?
Parameter	<char> = {INTernal, EXTernal} • INTernal – Periodic mode with internal triggering: One acquisition will be performed every Triggering Interval[26] seconds. • EXTernal - External trigger will be used for the initiating the acquisition cycle. If the acquisition cycle includes multiple shots, the first shot will be done on external trigger, all the following shots in the cycle will be started with the Triggering Interval[26] .
Query Response	{INTERNAL, EXTERNAL}
Notes	
Example	> TRIG:MODE INTERNAL > TRIG:MODE? < INTERNAL

5.2.2.1.8 Periodic acquisition interval

Description	This property sets or gets time in seconds between two consecutive acquisition in periodic (INTERNAL) mode.
Syntax	[SOURce:]TRIGgering:INTerval <time|char> [SOURce:]TRIGgering:INTerval?
Parameter	<time> = {10 MS to 1 s} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 10 MS • MAXimum - 1 S • DEFault - 10 MS • UP - increases the current value by 10 MS • DOWN - decreases the current value by 10 MS
Unit	Possible suffixes are: • S - seconds (default) • MS - milliseconds • US - microseconds • NS - nanoseconds • PS - picoseconds
Query Response	<time> in seconds
Notes	See also Acquisition Triggering Mode 25.

Example	`> TRIG:INT 100000 US`
	`> TRIG:INT?`
	`< 100.0E-3`

5.2.2.1.9 Input sampling rate

Description	This property gets or sets frequency in Hz for AD conversion of the input signal.
Syntax	[SOURce:]FREQuency <numeric|char> [SOURce:]FREQuency?
Parameter	<numeric> {25 | 50 | 100} in MHz <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 25 MHz • MAXimum - 100 MHz • DEFault - 25 MHz • UP - increases the current value • DOWN - decreases the current value
Unit	HZ - hertz
Query Response	<numeric> in Hz
Example	> FREQ 100 MHZ > FREQ? < 100000000

5.2.2.1.10 Transmitter burst frequency

Description	This property sets or gets the frequency in hertz for a pulse burst sent to a transmitting transducer.
Syntax	[SOURce:]TRANsmitter:FREQuency <frequency|char> [SOURce:]TRANsmitter:FREQuency?
Parameter	<char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 20 KHZ • MAXimum - 20 MHZ • DEFault - 5000 KHZ • UP - increases the current value by 1000 HZ • DOWN - decreases the current value by 1000 HZ
Unit	Possible suffixes are • HZ - Hertz • KHZ - kilohertz • MHZ - megahertz
Query Response	<frequency> in hertz
Notes	Due to implementation the period of the pulse is always a multiple of 10nS. For that reason, the real pulse frequency might differ from the requested one. For example, when Transmitter burst frequency[28] = 805 kHz (period ≈1242,23nS) is set, the real period of the impulse is 1240nS and the real pulse frequency is ≈806kHz.

Example	`> TRAN:FREQ 100 KHZ`
	`> TRAN:FREQ?`
	`< 100000`

5.2.2.1.11 Transmitter pulse amplitude

Description	This property sets or gets an amplitude in volts for a pulse burst sent to a transmitting transducer.
Syntax	[SOURce:]TRANsmitter:PULSe[:LEVel] <numeric|char> [SOURce:]TRANsmitter:PULSe[:LEVel]?
Parameter	<numeric> = {200 | 400 | 600} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 200 V • MAXimum - 600 V • DEFault - 200 V • UP - increases the current value • DOWN - decreases the current value
Query Response	<numeric> in volts
Notes	In this context, pulse voltage is the highest voltage of the half-wave. For example, a one-period-long 200V pulse peak-to-peak voltage is 400V (-200V to +200V).

Example	`> TRANsmitter:PULS 200 V`
	`> TRANsmitter:PULSe?`
	`< 200`

5.2.2.1.12 Transmitter burst period

Description	This property sets or gets the period in seconds for a pulse burst sent to a transmitting transducer.
Syntax	[SOURce:]TRANsmitter:PERiod <time|char> [SOURce:]TRANsmitter:PERiod?
Parameter	<char> = {MINimum | MAXimum | DEFault | UP | DOWN} <time> = {10 to 250 NS} • MINimum - 10 NS • MAXimum - 200 NS • DEFault - 140 NS • UP - increases the current value by 10 NS • DOWN - decreases the current value by 10 NS

Unit	Possible suffixes are: • S - seconds (default) • MS - milliseconds • US - microseconds • NS - nanoseconds • PS - picoseconds
Query Response	<time> in seconds
Notes	Transmitter burst frequency[28] and Transmitter burst period[29] change the same physical pulse parameter and the second is introduced for user's convenience. Transmitter burst frequency[28] = 10^6 / Transmitter burst period[29] . Due to implementation a pulse period is always a multiple of 10nS. For that reason, a real pulse period might differ from the requested one. For example, when Transmitter burst period[29] = 125 ns (frequency = 8000kHz) is set, the real period of the impulse is 120ns and the real pulse frequency is ~8333 kHz.

Example	`> TRAN:PER 200 NS`
	`> TRAN:PER?`
	`< 200E-9`

5.2.2.1.13 Transmitter burst duration

Description	This property sets or gets number of periods in transmitter burst.
Syntax	[SOURce:]TRANsmitter:DURation {numeric|char} [SOURce:]TRANsmitter:DURation?
Parameter	<numeric> = {0.5 to 8.0} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 0.5 • MAXimum - 8.0 • DEFault - 0.5 • UP - increases the current value by 0.5 • DOWN - decreases the current value by 0.5
Query Response	<numeric>
Notes	For example, when Transmitter burst duration[30] = 1, the pulse duration is one full period (negative and positive half waves), or 1uS for Transmitter burst frequency[28] = 1000 KHz. If the duration is 0.5, pulse duration is a half period. I.e. either positive or negative half-wave (depending on Transducer polarity mode[31]).

Example	`> TRAN:DUR 5`
	`> TRAN:DUR?`
	`< 5`

5.2.2.1.14 Transmitter enable

Description	This property defines if the transmitter generates pulse
Syntax	[:SOURce]:TRANsmitter:ENABle <char> [:SOURce]:TRANsmitter:ENABle?
Parameter	<char> = {OFF | ON | 0 | 1} • DEFault - OFF • OFF or 0 – no pulse will be generated. • ON or 1 – pulse will be generated according to other transmitter settings (amplitude, polarity, duration, frequency).
Query Response	{OFF | ON }
Example	> TRAN:ENAB ON > TRAN:ENABLE? < ON

5.2.2.1.15 Transducer polarity mode

Description	This property defines the initial polarity of the pulse burst generated at the transducer output
Syntax	[SOURce:]TRANsmitter:MODE <val> [SOURce:]TRANsmitter:MODE ?
Parameter	<char> = {OFF | ON | 0 | 1} • DEFault - OFF • OFF or 0 – the burst starts with the positive pulse. • ON or 1 – the burst starts with the negative pulse.
Query Response	{OFF | ON | 0 | 1}
Example	> TRAN:MODE ON > TRAN:MODE? < ON

5.2.2.1.16 Sound velocity

Description	This property sets or gets sound velocity used for thickness estimation
Syntax	[SOURce]:VELocity[:SOUNd] {numeric|char} [SOURce]:VELocity[:SOUNd]?
Parameter	<numeric> = {1000 to 10000} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 1000 • MAXimum - 100000 • DEFault - 3200 • UP - increases the current value by 1 • DOWN - decreases the current value by 1
Query Response	<numeric>
Example	> VEL 3456 > VEL? < 3456

5.2.2.1.17 Zonder mode

Description	This property switches between normal and eddy-current measurements
Syntax	[SOURce]:ZONDer:MODE <char> [SOURce]:ZONDer:MODE?
Parameter	<char> = {COMBINED | EDDY} • DEFault - COMBINED
Query Response	<char>
Notes	The value should be in '' or ""
Example	> ZOND:MODE "COMBINED" > ZOND:MODE? < COMBINED

5.2.2.2 SENSe Subsystem

5.2.2.2.1 Acquisitions per averaged vector

Description	A1570 can make several pulses/acquisitions in a row and internally calculate an averaged vector from the results, when Acquisitions per averaged vector[33] > 0.
Syntax	SENSe:AVERage:COUNt <numeric> SENSe:AVERage:COUNt?
Parameter	<numeric> = {0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13}
Query Response	<numeric>
Notes	Number of acquisitions required to produce one averaged data vector is calculated as 2 Acquisitions per averaged vector[33] .Acquisitions per averaged vector[33] does not affect the quantity of acquired data vectors sent to a client by A1570. For example, if Periodic acquisition interval[26] = 1000000 US and Acquisitions per averaged vector[33] = 3, one vector is sent by A1570 each second, and every sent vector is a result of internal averaging of $2^3 == 8$ acquisitions performed over a relatively short period of time (see Constant averaging interval[34] and Random averaging interval[35] for timings).

Example	`> SENS:AVER:COUNT 5`
	`> SENS:AVER:COUNT?`
	`< 5`

5.2.2.2.2 Constant averaging interval

Description	This property is defined in seconds and gets or sets a constant part of an interval between acquisitions in averaging mode. When A1570 performs several pulses/acquisitions in a row for the following averaging, a pause will take place after an acquisition is finished. It is calculated as FixedDelay + Constant averaging interval[34] + RandomInterval, where FixedDelay is a hardware delay of 22µs and RandomInterval is a random number in a range from 0 to Random averaging interval[35] .
Syntax	SENSe:AVERage:PERiod <time|char> SENSe:AVERage:PERiod?
Parameter	<time> = {1 to 100} US <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 1 US • MAXimum - 100 US • DEFault - 18 US • UP - increases the current value by 1 US • DOWN - decreases the current value by 1 US
Unit	Possible suffixes are: • S - seconds (default) • MS - milliseconds • US - microseconds • NS - nanoseconds • PS - picoseconds
Query Response	<time> in seconds
Notes	Default units are seconds.

Example	`> SENSe:AVERage:PERiod 50 US`
	`> SENSe:AVERage:PERiod?`
	`< 50.0E-6`

5.2.2.2.3 Random averaging interval

Description	This property is defined in seconds and gets or sets a random part of an interval between acquisitions in averaging mode. When A1570 performs several pulses/acquisitions in a row for the following averaging a pause will take place after an acquisition is finished. It is calculated as FixedDelay + Constant averaging interval[35] + RandomInterval, where FixedDelay is a hardware delay of 22µs and RandomInterval is a random number in a range from 0 to Random averaging interval[35].
Syntax	SENSe:AVERage:PERiod:RANDom <time|char> SENSe:AVERage:PERiod:RANDom?
Parameter	<time> = {1 to 10} US <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 1 US • MAXimum - 10 US • DEFault - 1 S • UP - increases the current value by 1 US • DOWN - decreases the current value by 1 US
Unit	Possible suffixes are: • S - seconds (default) • MS - milliseconds • US - microseconds • NS - nanoseconds • PS - picoseconds
Query Response	<time> in seconds
Notes	For example, when Acquisitions per averaged vector[33] = 1, Constant averaging interval[34] = 100 us and Random averaging interval[35] = 10 us, the second acquisition will take place in 122-132 µs after the first acquisition is finished.

Example	`> SENSe:AVER:PER:RAND 2 US`
	`> SENSe:AVER:PER:RAND?`
	`< 2.0E-6`

5.2.2.2.4 Magnet delay

Description	This property is defined in seconds and gets or sets a delay between starting of magnet and acquisition begin if the magnet is enabled with Magnet enabled[37] .
Syntax	[:SENSe]:MAGNet:DELay <time|char> [:SENSe]:MAGNet:DELay?
Parameter	<time> = {10 to 1300} US <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 10 US • MAXimum - 1300 US • DEFault - 650 US • UP - increases the current value by 1 US • DOWN - decreases the current value by 1 US
Unit	Possible suffixes are: • S - seconds (default) • MS - milliseconds • US - microseconds • NS - nanoseconds • PS - picoseconds
Query Response	<time> in seconds
Notes	

Example	`> MAGNet:DELay 20 US`
	`> MAGNet:DELay?`
	`< 20.0E-6`

5.2.2.2.5 Magnet enabled

Description	This property gets or sets enabling magnet during the acquisition.
Syntax	[:SENSe]:MAGNet:ENABle <char> [:SENSe]:MAGNet:ENABle?
Parameter	<char> = {OFF | ON | 0 | 1} • DEFault - OFF • OFF or 0 – no magnet will be turned on. • ON or 1 – magnet will be turned on.
Query Response	{OFF | ON }
Notes	
Example	> MAGNet:ENABle OFF > MAGN:ENAB? < OFF

5.2.2.2.6 Magnet voltage

Description	This property gets or sets an amlitude in Volts for turning of the magnet (if it is enabled with Magnet enabled 37)
Syntax	[:SENSe]:MAGNet:VOLTage <numeric|char> [:SENSe]:MAGNet:VOLTage?
Parameter	<numeric> = {15 to 25} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 15 V • MAXimum - 25 V • DEFault - 20 V • UP - increases the current value by 1 V • DOWN - decreases the current value by 1 V
Query Response	<numeric> in Volts
Notes	
Example	> MAGNet:VOLTage 20 > MAGN:VOLT? < 20

5.2.2.2.7 Processing probe delay

Description	This property gets or sets a probe delay used for thickness measurement
Syntax	[SENSe]:PROBe:DELay[:PROCessing] <numeric|char> [SENSe]:PROBe:DELay[:PROCessing]?
Parameter	<numeric> = {0 to 100} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 0 MS • MAXimum - 100 MS • DEFault - 0 MS • UP - increases the current value by 1 MS • DOWN - decreases the current value by 1 MS
Query Response	<numeric> in microseconds
Notes	This property will be overwritten after calibration on object (see Start calibration on object 24).
Example	> PROB:DEL 20 > PROB:DEL? < 20

5.2.2.2.8 Probe type

Description	This property gets or sets a probe class used for calibration and thickness measurement
Syntax	[SENSe]:PROBe[:TYPE] <string> [SENSe]:PROBe[:TYPE]?
Parameter	Supported classes: • S3850 • S3950 • S7392 • S7394 • S3951 • S3855 • S3955 • S7692 • S7694
Query Response	Current probe class
Notes	This property should be set before starting calibration or thickness measurement. The value should be in '' or ""

Example	`> PROB "S7394"`
	`> PROB?`
	`< S7394`

5.2.2.2.9 Dead zones

Description	This property gets or sets dead zones for calibration on object and thickness measurement
Syntax	[SENSe]:DEZones <string> [SENSe]:DEZones?
Parameter	List `gain:value` separated with semicolon (;)
Query Response	List `gain:value` separated with semicolon (;)
Notes	Each dead zone value is set in ADC samples (from 0 to 8192) This property will be overwritten during calibration in air (see Start calibration in air 23) The value should be in '' or ""

Example	`> SENSe:DEZones '0:10;5:11;10:12;15:13;20:14;25:15;30:16;35:17;40:18'`
	`> SENSe:DEZones?`
	`< 0:10;5:11;10:12;15:13;20:14;25:15;30:16;35:17;40:18`

5.2.2.2.10 Noise properties

Description	This property gets or sets noise properties used during thickness estimation with pulse magnets
Syntax	[SENSe]:CALibration:NOISe <string> [SENSe]:CALibration:NOISe?

Parameter	JSON with format:
	`{`
	`  "command" : "noise_function",`
	`  "noise_end" : 700,`
	`  "noise_level" : 306,`
	`  "noise_start" : 400`
	`}`

Query Response	JSON with noise properties
Notes	Should be written as one line without `\n` symbols. JSON-string should be enclosed with `' '`. JSON should contain string element `"command"` equals to `"noise_function"` JSON may contain no or more noise parameters. If some parameters are not in the JSON, their setting will be skipped. I.e. the following content is valid (but makes little sense): `{ "command" : "noise_function" }` This property will be overwritten during calibration of pulse magnet probe in air (see Start calibration in air 23)

Example	`> SENSe:CALibration:NOISe`
	`'{"command" : "noise_function",`
	`"noise_end" : 222, "noise_level" : 333,`
	`"noise_start" : 111}'`
	`> SENSe:CALibration:NOISe?`
	`< {"command" : "noise_function",`
	`"noise_end" : 222,`
	`"noise_level" : 333,`
	`"noise_start" : 111}`

5.2.2.2.11 Eddy current properties

Description	This property gets or sets properties of eddy-current signal used during contact detection with pulse magnet probes
Syntax	[SENSe]:CALibration:EDARray <string> [SENSe]:CALibration:EDARray?

Parameter	JSON with format:
	`{`
	`"command": "calibration_eddy_array",`
	`"eddy": [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10,...] ,`
	`"eddy_start" : 30`
	`}`
	Where element `"eddy"` contains array of 64 elements values of ground eddy signal to be used in contact detection for pulse magnets.

Query Response	JSON with eddy signal properties
Notes	The value should be written as one line without `\n` symbols inside. `"eddy_start"` is the start sample in eddy vector where valuable signal starts. JSON-string should be enclosed with `' '`. JSON should contain string element `"command"` equals to `"calibration_eddy_array"` JSON may contain no or more eddy parameters. If some parameters are not in the JSON their setting will be skipped. I.e. the following content is valid (but makes little sense): `{ "command": "calibration_eddy_array" }` This property will be overwritten during calibration of pulse magnet probe in air (see Start calibration in air 23)
Example	`> SENSe:CALibration:EDARray '{"eddy": [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63], "eddy_start" : 30, "command": "calibration_eddy_array"}'` `> SENSe:CALibration:EDARray?` `< {"eddy": [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63], "eddy_start" : 30, "command": "calibration_eddy_array"}`

5.2.2.2.12 Software averaging enabling

Description	The property sets or gets enabling of "infinite" software averaging for thickness measurement
Syntax	[SENSe]:SOAVerage[:ENABle] <char> [SENSe]:SOAVerage[:ENABle]?
Parameter	<char> = {ON, OFF} • DEFault - OFF
Query Response	<char>
Notes	Software averaging should be configured with Software averaging limit 42 as well
Example	> SOAV ON > SOAV? < ON

5.2.2.2.13 Software averaging limit

Description	The property sets or gets number of measurements in one "infinite" software averaging
Syntax	[SENSe]:SOAVerage:COUNt {numeric|char} [SENSe]:SOAVerage:COUNt?
Parameter	<numeric> = {1 to 100} <char> = {MINimum | MAXimum | DEFault | UP | DOWN} • MINimum - 1 • MAXimum - 100 • DEFault - 1 • UP - increases the current value by 1 • DOWN - decreases the current value by 1
Query Response	<numeric>
Notes	To enable the "infinite" software averaging, you should use Software averaging enabling 42
Example	> SOAV:COUN 55 > SOAV:COUN? < 55

5.2.2.3 FETCh Subsystem

5.2.2.3.1 A-Scan fetching

Description	This query requests one a-scan data from the instrument
Syntax	FETCh[:ARRay]?
Query Response	<binary data>
Notes	Fetching data should be performed after acquisition start. If the data is requested prior the start, a time-out error might be thrown (depending on SCPI client settings)

Example	`> FETC:ARR?`
	`< #516412D...D`
	Where:
	• # - always sent before definite block data (ASCII format)
	• 5 - specifies that the byte count is five digits (16412) (ASCII format)
	• 16412 - specifies the number of data bytes that will follow, not counting <NL><END> (ASCII format)
	• D...D - 16412 bytes (ASCII format)
	where first 28 bytes is a vector header with meta-information
	• in the header bytes 16, 17 is a word with vector index (a counter of vectors started after the first data acquisition).
	the last 16384 bytes is a vector of 8192 2-bytes signed words in little-endian format

5.2.2.3.2 Fetching measurement result

Description	This query requests the last thickness measurement result
Syntax	[FETCH]:RESult[:MEASure]?

Query Response	<string>
	JSON containing all measurement properties.
	Format:
	`{`
	`"command": "measurement_result",`
	`"contact": false,`
	`"contact_quality": 0,`
	`"counter" : 0,`
	`"gain": 0,`
	`"thickness": 65535,`
	`"timestamp" : "12:10:49"`
	`}`
	
	`command` - identifier of the result, always `"measurement_result"`
	`thickness` is returned in micrometers as integer value. Values `65535` and `-1` should be interpreted as failed measurement (e.g. no contact with object found).
	`counter` - 32-bit iterator which is incremented each finished measurement, starts from 0.
	`gain` - analog gain estimated during the measurement
	`timestamp` - string with time of the last finished measurement.
	`contact` - boolean describing presence of contact.
	`contact_quality` - estimated quality of contact:
	0 - No Contact,
	1 - Low Contact,
	2 - Medium Contact,
	3 - Full Contact

Notes	The result of a measurement is saved internally for future requests until the next measurement is completed. • **Repeat Requests**: If no new measurement has started, the command will return the same JSON data each time. • **Multiple Measurements**: If several measurements are completed between requests, only the most recent result will be delivered.
Example	`> RES?` `< {"command": "measurement_result", "contact": false,"contact_quality": 0, "counter" : 0, "gain": 0, "thickness": 65535, "timestamp" : "12:10:49"}`

5.2.2.4 SYSTem Subsystem

5.2.2.4.1 Reads out error message queue

Description	This method reads out error message queue.
Syntax	SYSTem:ERRor?
Query Response	<numeric>,<string>
Example	> SYSTem:ERRor? < 0, "No error" > SYSTem:ERRrr? > SYSTem:ERRor? -113,"Undefined header;Command: SYST:ERRrr"

5.2.2.5 STATus Subsystem

5.2.2.5.1 Battery state of charge

Description	Read battery state of charge in %
Syntax	[STATus]:BATTery?
Query Response	<numeric> = {0 - 100}
Example	> BATT? < 55

5.2.2.5.2 Charging status

Description	Read charging status
Syntax	[STATus]:CHSTatus?
Query Response	<char> = {OFF | IDLE | CHARGING | DONE | ERROR}
Example	> CHST? < DONE

5.3 SCPI Examples

Comprehensive examples can be found in the GitHub repository of ACS-Solutions GmbH:

https://github.com/Acoustic-Control-Systems/a1570